STRATEGY PAPER FOURTEEN

Department of
War Studies

EUCERS
European Centre for Energy and Resource Security

KING'S College LONDON

UK's Dash for Gas:
Implications for the role of natural gas in European power generation

Alexandra-Maria Bocse & Carola Gegenbauer

EUCERS Advisory Board

Media Partners

independent · international · incisive energy post

ICIS

BIZZ energy today.

Design
Calverts
www.calverts.coop
Approved by
brand@kcl.ac.uk
February 2017

Impressum

Published by

The European Centre for Energy and Resource Security (EUCERS) Established in the Department of War Studies at King's College London in October 2010. The research of EUCERS is focused on promoting an understanding of how our use of energy and resources affects International Relations, since energy security is not just a matter of economics, supply and technological change. In an era of globalization energy security is more than ever dependent on political conditions and strategies. Economic competition over energy resources, raw materials and water intensifies and an increasing number of questions and problems have to be solved using holistic approaches and wider national and international political frameworks.

www.eucers.eu

About the authors

Alexandra-Maria Bocse has extensive experience researching on international governance, energy security and energy politics at University of Cambridge, Harvard University and King's College London. She completed an MPhil in International Relations at University of Cambridge, UK and conducted research for a PhD on European energy security at the same institution. She taught at both undergraduate and graduate levels European Politics, Global Energy and Environmental Politics and International Affairs in Cambridge and London.

Carola Gegenbauer is the operations coordinator of the European Centre for Energy and Resource Security (EUCERS). She holds an MA in European Studies from the Center for European Integration Studies (ZEI) at the University of Bonn, Germany, where she is also currently working on her PhD. Her research focuses on energy policy and the European integration process and how crises and conflicts over energy have had an impact on energy related integration and the development of an EU Energy Union.

Contents

List of figures

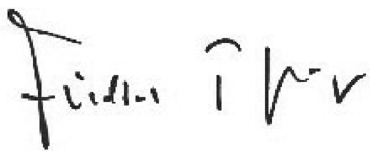
Foreword

It is my pleasure to introduce the fourteenth EUCERS Strategy Paper. This strategy paper, published by the European Centre for Energy and Resource Security (EUCERS), reviews the UK's *dash for gas* and evaluates implications for the role of gas in European power generation.

The fourteenth EUCERS Strategy Paper aims to isolate the factors that led to the UK's *dash for gas* (the transition from traditional coal to modern gas-fired power plants in the UK's electricity sector), investigate the degree to which similar conditions are currently present in Europe and advance a series of policy recommendations for enhancing the prospects of natural gas as a partner to renewable energy in power generation in Europe, given the EU's commitment to fighting climate change.

This paper analyses the main factors (political, technological, financial and environmental) that determined the 1990s UK's *dash for gas* and discusses the degree to which the same factors could currently generate a shift towards natural gas in power generation in Europe and its Member States. In addition, it examines complementary measures that the UK took in preserving the changes triggered by the *dash for gas* and in providing incentives for climate friendly power generation, such as the carbon price floor. Finally, the paper makes policy recommendations on measures that could support the use of gas in power generation in Europe and Germany.

I would like to take the opportunity to thank our authors, Alexandra-Maria Bocse, Research Associate and KAS Fellow 2016/17 at EUCERS and Carola Gegenbauer, Operations Coordinator at EUCERS for writing this very important and insightful study. A special thank you goes to Zukunft Erdgas GmbH for financially supporting this research study.



Executive summary

This study aims to isolate the factors that led to the UK's *dash for gas* (the transition from traditional coal to modern gas-fired power plants in the UK's electricity sector), investigate the degree to which similar conditions are currently present in Europe and advance a series of policy recommendations for enhancing the prospects of natural gas as a partner to renewable energy in power generation in Europe, given the EU's commitment to fighting climate change.

The study investigates in the first part the factors that determined the UK's *dash for gas*, which began in the early 1990s. The study argues that the UK's dash was not a product of a singular factor, but of a combination of factors that generated it: the privatization of the energy sector promoted by successive British conservative governments, regulatory changes at the EU and national levels that facilitated the use of gas in power generation, technological changes that increased the efficiency of combined cycle gas turbines (CCGT), the availability of cheap gas on the British market as a result of the increase in production of British North Sea gas, as well as the reduced amount of carbon dioxide and sulphur dioxide emissions produced in gas-fired power stations by contrast to coal-fired stations.

The second part of the study argues that several recent developments taking place at European level hold a lot of promise for a bright gas future in power generation in Europe. The study points to the low price of gas and its lower environmental footprint (by contrast to coal) that will give gas a competitive advantage especially if the reform of the EU-ETS (EU Emissions Trading System) leads to the effective pricing of carbon. Carbon pricing can increase the competitiveness of gas in power generation in relation to coal. Technological limitations prevent power generation entirely from renewable sources and reduce the attractiveness of coal (given the lack of progress in carbon capture and storage, CCS) and nuclear power (as accidents such as those at Fukushima power plant indicate that technological means to manage the unexpected are limited). However, there are several areas of uncertainty and risk that might compromise the prospects of natural gas. These areas include Brexit, a new presidential administration in the United States, as well as several regulatory debates taking place at the EU level (potential tougher methane emission regulations, disclosure of private natural gas contracts and the strong opposition to Nord Stream 2 and its implications for the broader acceptance of natural gas in Europe).

The last part of the study advances several policy recommendations (directed mainly towards governmental and supranational, European Union, actors) that would enable gas to play a greater role in power generation in Europe. Gas can ensure the stability of the grid in a climate friendly way and cover the capacity needed when power generation from renewable sources is low. The study therefore recommends:

- Providing financial incentives for power generation to rely more on gas in Europe, in general, and in Germany. in particular;
- Effectively pricing carbon: by reforming the EU-ETS and complementing it with carbon taxes and carbon floors at both the EU and Member States levels;
- EU to maintain its climate commitments and maintain relations both with Britain after Brexit and the US after President Trump takes office and engage these countries on climate issues (through diplomacy and issue linkage);
- Developing technology that allows for a better integration of both gas and renewable generated power in the grid;
- Reshaping European understandings of energy security so there is an increased acceptance of gas as a reliable power source no matter the origin of the gas molecule.

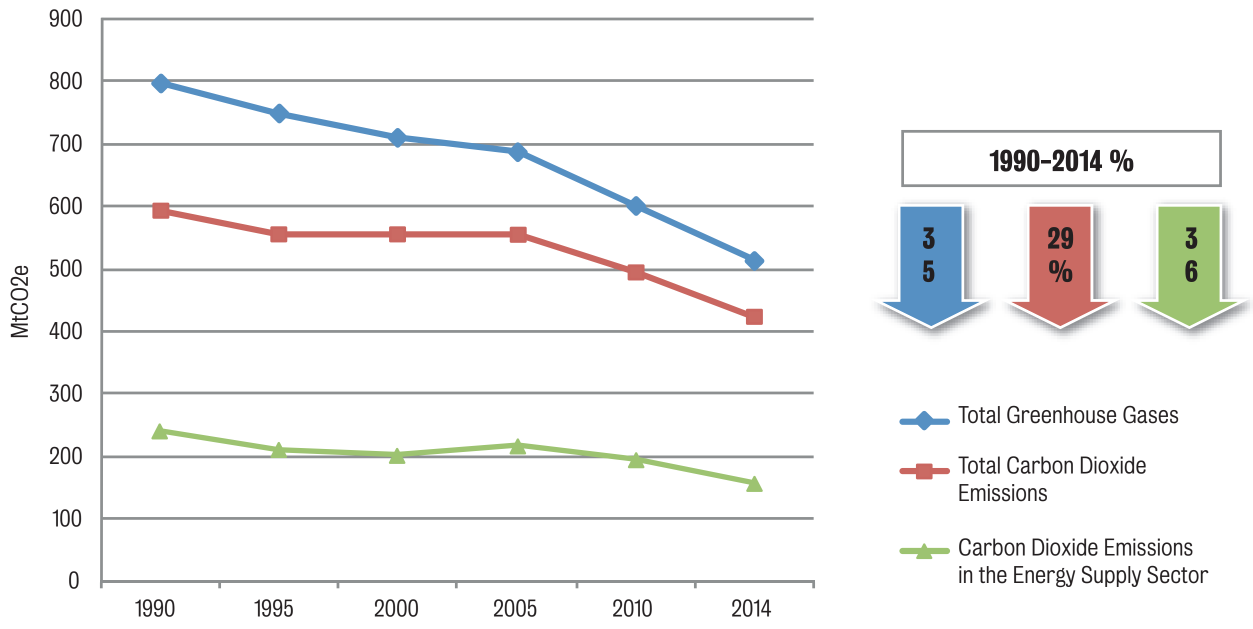
Introduction

At the beginning of the 1990s, the United Kingdom began its transition from its traditional coal to modern gas-fired power plants in its electricity sector. As a result, in May 2016, UK coal power plants produced for the first time in over a century no electricity at all for over 12 hours. In the UK, in the second quarter of 2016, gas accounted for a share of 45.2% in electricity generation, renewable energy for 24.9%, nuclear for 21.3%, while coal only for 5.8% (Department for Business, Energy and Industrial Strategy, UK Government 2016, p.37). The share of coal decreased from 20.3% in the second quarter of 2015 to 5.8% in the second quarter of 2016, while at the same the share of gas rose from 29.9% to 45.2% (Department for Business, Energy and Industrial Strategy, 2016, p.36). The case of UK's *dash for gas* shows that indeed it is possible to shift from a coal to a gas-based power generation system. Such a shift has the potential to reduce the carbon footprint of the power sector. The *dash* contributed to reducing the United Kingdom's CO_2 emissions by a third between 1990 and 2014.

During this process, gas also increasingly became a necessary, efficient and flexible partner for renewable energy in the UK. The commitment that the EU and its Member States took in Paris in 2015 to reduce their GHG emissions will impact the European energy system. Gas use in power generation could also help the EU meet its climate commitments given the gas lower carbon footprint and the consistency it brings to generation when used in combination with renewable sources.

This paper will analyse the main factors (political, technological, financial and environmental) that determined the 1990s UK's *dash for gas* and will discuss the degree to which the same factors could currently generate a shift towards natural gas in power generation in Europe and its Member States. In addition, it will discuss complementary measures that the UK took in preserving the changes triggered by the *dash for gas* and in providing incentives for climate friendly power generation, such as the carbon price floor. The last part of the paper will focus on making policy recommendations on measures that could support the use of gas in power generation in Europe and Germany. We move now to the first part of the paper which offers insights into the drivers behind the *dash for gas* in the UK.

Figure 1: Decline in UK greenhouse gas (GHG) emissions



Source: Figure generated by the authors of the study based on data from the Department of Energy and Climate Change 2016

The driving forces behind the *dash for gas* in the UK

This section of the paper will briefly investigate the factors that led to the UK's *dash for gas* in order to uncover lessons that can be learnt for a similar transition of a wider scale in Europe. There is an agreement in the literature and among most policy-makers that the *dash for gas* was triggered by a combination of factors acting in conjunction (Spooner 1995; Winskel 2002) and that the scale of the phenomenon would not have been so wide in the absence of the interaction of these factors. According to Winskel the *dash for gas* was not a planned event and can be best understood: 'as a contingent and largely unplanned outcome of the interplay of previously excluded international forces with latent local interests, mediated by policymaking expediency' (Winskel 2002, p.563). The first set of forces that determined the *dash for gas* in the UK, are political. The privatization of the electricity industry in the UK, as well as regulatory changes in the regime of natural gas played an important role in the *dash for gas*.

Privatization of the electricity industry

The late 1980s and early 1990s were characterized by a widespread phenomenon of privatization of public companies and utilities in the UK promoted by successive conservative governments and the most prominent British political figure at that time, Margaret Thatcher[1]. The UK Conservative government was committed to the liberalization of markets, private ownership and consumer choice and this led to a policy promoting the privatization of the energy industries (gas, electricity and coal) (Spooner 1995). Several energy companies (Britoil, British Gas and British Petroleum) were privatized during the 1980s and early 1990s. In the last stages of the privatization process (1992-1996), the sell-off of British Coal was completed, as well as the privatization of companies such as Powergen and National Power, both involved in power generation.

According to Winskel (2002), although it was not the only factor responsible for the *dash*, the privatization of energy utilities contributed to its scale and speed. Sources in the industry shared this point of view. For instance, the Director of Engineering at Rolls-Royce Industrial Power Group claimed that 'without privatization there would have been a slower switch to gas, in practice what we have seen is a revolution' (interviewed by Winskel 2002, p.580). Privatization allowed a new set of players to enter the market and make it more competitive. The British Government broke up the monopoly of the generation and transmission company, the Central Electricity Generating Board (CEGB).

The British case was an extreme case in the type of reforms adopted and impact produced, but it reflected international tendencies related to the liberalisation and privatisation of utilities (Winskel 2002). In a liberalised market, new and well-established energy producers are aware they need to keep prices low in order to remain competitive and to show flexibility in answering fluctuations on the market. At the same time, British developments served as a model for energy market liberalisation moves taking place Europe-wide. Some of the principles advanced in the UK in the 1980s and 1990s were transferred to the European level at a later stage: principles such as ownership unbundling and third party access that characterize the EU energy market under the Third Energy Package (2007). Unbundling prohibits an entity to own energy generation, transmission, and sale facilities simultaneously, while third party access rules grant access to networks to those who do not own the actual physical network infrastructure in order to encourage competition and the functioning of the energy market.

Regulatory changes in power generation

At the beginning of the 1990s, there was an important change in the European regulations regarding electricity generation. In 1991, the European Community 1975 Directive that prohibited the use of gas in power stations was repealed (Spooner 1995). The directive was meant to reduce the EU energy insecurity generated by the dependence on imported fossil fuels, such as gas. This regulatory change directly impacted the British regulatory framework and opened an opportunity for gas to enter the electricity generation field. Therefore, regulatory changes were equally important in enabling gas to be used as a fuel in power generation

Technological changes

A second important set of factors is related to technological changes and to a certain degree the social acceptance of different electricity generation technologies in the 1980s and 1990s. Technological developments in electricity generation made an important contribution to the *dash for gas*. The combined cycle gas turbine (CCGT) generators were characterized by a high degree of efficiency: 'in the combined-cycle, waste heat from the gas turbines is used to raise steam for second-phase generation, giving efficiency levels of between 45 and 50 per cent compared to c.[2] 35 per cent in conventional coal-fired plants' (Spooner 1995,

1 Privatisation was not restricted to the energy sector, as it targeted sectors as diverse as telecommunications, car manufacturing, etc. (Seymour 2012), but it did make a substantial impact on this particular sector.

2 'c.' stands for 'circa'/'approximately'.

p.403). At the same time, power stations using the CCGT could be erected and introduced in the production cycle in two years. The Roosecote Power Station was built in 24 months and had a capacity of 229 MW. The Glanford Brigg station was built in only 26 months and had a generation capacity of 260 MW. The new plants were built for an economic life cycle that overlapped with the bank loan, power purchase agreement and supply contract (Winskel 2002). From a perspective, they were more secure, predictable investments. They offered the investors the prospect of getting a return on their investment in 15 years, not in a longer span, as it was the case with conventional plants. CCGT was a technology less capital intensive (Andrews 1988) and could be competitive in smaller units[3]. The CCGT technological revolution took place in the US and impacted other energy markets, including the UK market. As acknowledged in the existing literature, the *dash for gas* was made possible to an important degree by the UK energy industry reconnecting with the international dynamics in technological changes and fuel economy (Winskel 2002).

The outbreak in CCGT technologies coincided with a period of increased contestation of an alternative power generation technology: nuclear technology. The 1979 reactor meltdown at the Three Mile Island nuclear facility in the US and the 1986 nuclear accident in Ukraine led to increased public opposition to nuclear energy. At the same time, low environmental performance negatively impacted the prospects of coal and oil, while solar and wind energy generation technology was still prohibitively costly to constitute a feasible alternative to coal and nuclear energy (Smith and Sharpe 1995). Increased availability and the drop in the price of gas complemented technological drivers.

Cheaper gas as a contributing factor to the *dash for gas*

The availability of cheaper gas also contributed to the *dash for gas*. In the late 1980s and early 1990s the price of gas available on the international and British market dropped (Schaefer 2009 based on US Energy Information Administration and US Department of Commerce data). The discovery and exploitation of North Sea gas was a major factor behind the drop in the price of gas on the British market. UK's North Sea based gas production gradually increased from the mid 1970s to the 1990s and reached its peak in the late 1990s (BP 2014). There is a substantial chronological overlap between the increase of gas production in the UK and the beginnings of the *dash for gas*.

3 Its success explains also the success of fracking in the United States in recent years (that enabled the shale gas revolution in the US) as hydraulic fracturing is also less capital intensive and can bring profit in smaller units than facilities using conventional drilling technologies. A combination of high oil prices and cheap financing made hydraulic fracturing economically feasible.

The low gas price created a strong incentive for the use of gas in power generation, especially under the conservative Thatcher government when market considerations became more important in the process of assessing the merits of different power generation options. In June 1990 the House of Commons Energy Committee concluded that CCGT power generation is more advantageous than any alternative when it comes to costs (House of Commons Energy Committee 1990). In 1990, for the British industrial sector, the price of gas and coal reached parity (Department of Trade and Industry 1997). In the mid 1990s, governmental estimates showed that the cost of power generated from CCGT is lower than that of power generated in nuclear facilities (2.5-2.8p/kWh by contrast with 2.9p/kWh) (Department of Trade and Industry and the Scottish Office 1995).

Furthermore, the development of North Sea oil and gas meant that reliance on gas implied reliance on a secure, indigenous, highly available energy resource, not only on a cheaper resource. In addition, diversification away from coal responded to potential energy security concerns. Energy security was associated with a diverse energy mix. Yorkshire Electricity, for instance, was of the opinion that by ensuring a mix of sources in electricity generation the risk of interruption of supply or increase in price of a particular fuel is limited (Yorkshire Electricity 1995).

Next to price and reliability, also environmental considerations played a role in the *dash for gas*. Although the environmental movement was less strong in the late 1980s and beginning of the 1990s than it is now, the environmental drivers of the *dash* cannot be ignored.

Environmental considerations

The switch to gas helped the UK to contribute to the international effort against climate change and in preventing acid rain, the latter being a major environmental concern in the 1980s. The UK became part to the 1992 UN Framework Convention on Climate Change and took on the obligation to reduce its greenhouse gases levels to the level of 1990 by 2000. The burning of gas in power generation is less polluting for the atmosphere than coal and oil: 'CCGTs emit approximately 60 per cent the carbon dioxide of an equivalent-sized conventional coal-fired station, and 80 per cent of oil-fired. No ash or dust is produced. It has been calculated that 1GW of CCGT plant replacing the equivalent capacity of coal-fired saves c.3 million tonnes of CO_2 p.a.' (Spooner 1995, p.403). In addition, CCGT power stations led to a high fuel utilization rate that resulted in fuel savings and reduced environmental emissions (Spooner 1995, p.394). By contrast to coal, the full cycle environmental impact of gas in power generation is modest. Even though the leakage of unburned gas such as methane generates greenhouse gas effects, it remains in the atmosphere for a much lesser time than CO_2 (US Environmental Protection Agency 2016a).

As briefly mentioned above, one of the environmental challenges that dominated the international and European agenda in the years preceding the *dash* was the fight against acid rain. Acid rain is triggered by the sulphur dioxide and nitrogen oxide in the atmosphere. In the 1980s, many governments, including the UK took a commitment to reduce these emissions. Legislation generated at the European level, such as the 1988 Large Combustion Plants Directive, created an additional incentive for the UK to reduce national SO_2 emissions. The binding directive demanded progressive reductions in their SO_2 emissions from Member States. The UK signed the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions to the Convention on Long-Range Transboundary Air Pollution. Consequently, the UK had to reduce its SO_2 levels with 70% by 2005 and with 80% by 2010 (having as a reference point 1980 levels). Coal-fired power stations were the main producers of such emissions. They needed to resort to flue-gas desulfurization (FGD) to remove sulphur from their stack gases and the process would remove up to 95% of the SO_2, but FGD increased the price of running a coal plant. Pricewise, it was simply cheaper to opt for building more gasified plants than coal ones with FGD equipment (the Managing Director of National Power 1993). The FGD placed a cost on pollution that increased the cost of coal-fuelled power generation.

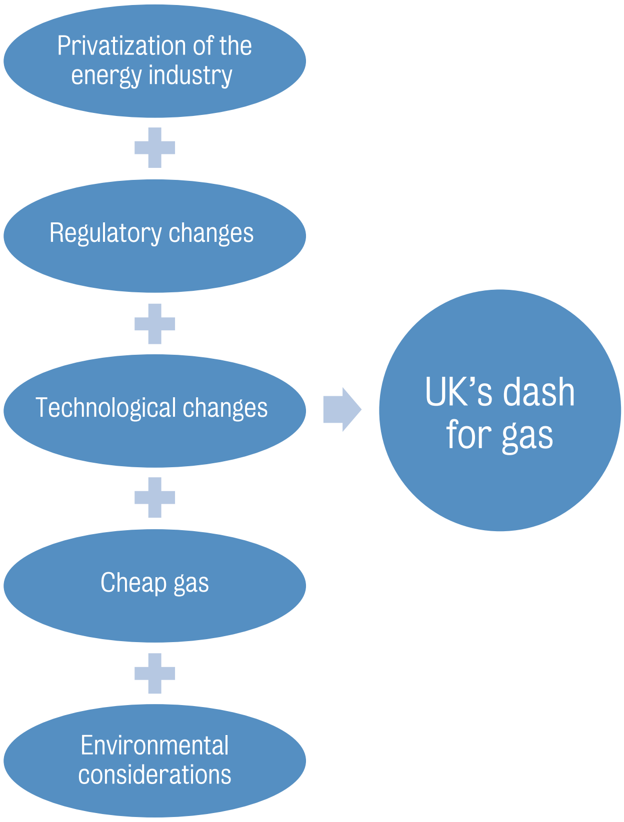
The next section will analyse what can be learned from the UK's *dash for gas* and possibly applied to greater Europe. We will then analyse the degree to which UK's *dash* drivers are currently present at the European level (and shared at the level of EU Member States) in order to assess what role gas can play in European power generation over the next years. The last section will discuss what complementary measures can be taken (financial, regulatory, political, etc.) in order to enhance the prospects of gas in the European energy mix.

What we can learn from the *dash for gas* in the UK

The UK's *dash for gas* is the result of a set of drivers that acted in conjunction. To an important degree, it was the result of serendipity, rather than the product of careful policy design. Although governmental policy (the liberalization of the energy market) and changes in regulation contributed to creating the right political environment for the *dash for gas*, the scale of the *dash* was the product of the synchronization of these factors with the presence of cheaper and more secure gas, as well as developments in the CCGT technology and environmental concerns. The figure below illustrates the various factors that triggered the *dash*, as well the relationships of interdependence that are established between them.

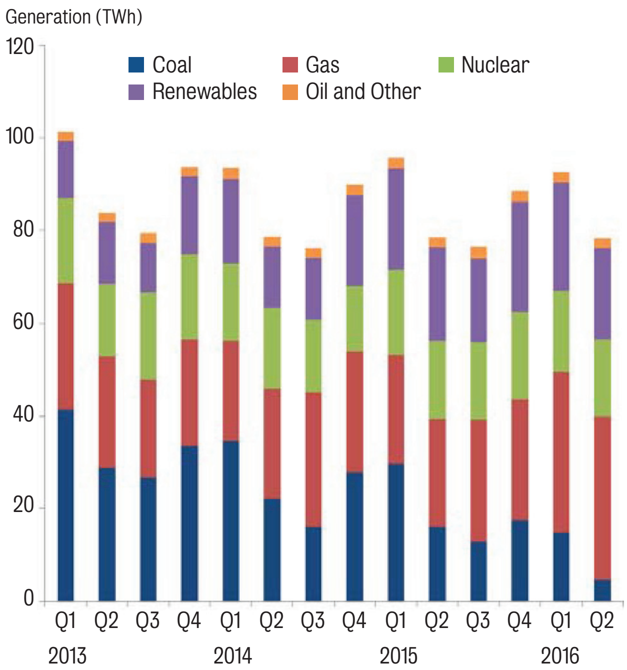
All these factors supported in the 1990s a process that led to an increased role of gas in the UK energy mix. Currently gas is an important partner of renewable sources in energy generation in the UK.

Figure 2: The drivers behind the *dash for gas* in the UK



Source: Figure developed by the authors of the study

Figure 3: Electricity generation in the UK by fuel type



Source: Department for Business, Energy and Industrial Strategy, UK Government 2016

As the sections above showed, there was quite a lot of enthusiasm in the 1990s in the UK when it comes to the presence of gas in power generation. The sentiment regarding the *dash for gas* has varied in the UK starting with the 2000s. After the North Sea UK gas exploitation peaked, there was concern about increase in the gas prices. In this context, the UK's *dash for gas* could also be associated with decreased energy supply security by increasing import dependency, as gas had to be imported, while coal was domestically available. Although, financially speaking, the *dash* may have not been a success story 10 years ago, today, from a climate perspective the *dash* can be regarded as a success. Today, the UK is benefitting from strengthening gas in its energy mix over the last decades as it helps it achieve its climate goals. Given the high interest that the EU currently has to prevent irreversible climate change from taking place, it is pertinent and timely to explore what are the prospects of gas in power generation in Europe.

An enhanced role for gas in European power generation

Gas currently plays an important role in the European energy mix, but there is a lot of potential for increasing the contribution that gas currently makes to European power generation. In 2015, gas consumption in Europe was 400 bcm and it decreased by 1% in the first quarter of 2016 (European Commission 2016a, p.2). Gas accounts for a fifth of the EU-28 gross inland consumption of energy (European Commission, DG Energy 2016, p.22). Currently, the share of gas in gross electricity generation in the European Union is 15.4% (European Commission, DG Energy 2016, p.90). In Germany, gas accounts for 11.59% of electricity generation (European Commission, DG Energy 2016, p.90)[4]. Gas became more important in electricity generation in Germany in 2013 making a contribution particularly in the winter months (European Commission 2016a, p.7). In Germany, gas-fired power generation accounted for 5% of the total generation in the fourth quarter of 2014, 10% in the fourth quarter of 2015 and its share increased to almost 12% in the first quarter of 2016 (European Commission 2016a, p.7). This was a result of the increased competitiveness of gas in Germany in this particular sector.

Low gas prices

Similarly to the situation faced by the UK in the 1990s, the European Union and its Member States are currently benefiting from low gas prices. European prices are higher than those in the United States, but the difference has decreased if considered in absolute terms and the gap between Asian LNG prices and European hub prices almost closed by March 2016 (European Commission 2016a, p.2). Low oil prices, the high availability of LNG and pipeline gas, as well as relatively warm winter temperatures contributed to the reduction of European hub gas prices. As certain gas prices are linked to the price of oil[5], the decrease in the price of oil on the international markets triggered a decrease in the price of natural gas in recent years (European Commission 2016a, p.2). The same low gas price was enjoyed by the individual EU Member States, such as Germany: 'the average German border price was 5.8 USD/mmbtu (18.2 Euro/MWh) in the fourth quarter of 2015 and 4.9 USD/mmbtu (15.2 Euro/MWh) in the first quarter of 2016' (European Commission 2016a, p.21). In 2015 'the German border price closely followed the development of the NBP spot price (on average, it was only 0.1 USD/mmbtu higher) which seems to indicate that Germany's gas trading partners have turned to hub based pricing' (European Commission 2016a, p.21). According to the European Commission, the decrease in the gas price 'improved the relative competitiveness of gas-fired generation vis-à-vis coal in many markets and gas deliveries to power plants increased at the end of 2015 and the beginning of 2016' (European Commission 2016a, p.7). As no major increases in the price of oil and gas are expected in the near future[6], it can be argued that there is a strong incentive for the use of gas in power generation.

However, the gas financial competitive advantage is limited by the fact that the decrease in the price of gas in recent years was matched by a decrease in the price of coal available to European consumers (European Commission 2016a, p.7). The shale gas revolution in the US led to the situation in which a lot of coal dedicated to the US market was redirected to the European market determining a price decrease. Gas has an advantage when it comes to coal if assessed based on its environmental footprint: gas power plants generate less GHG emissions. As the next section will show, the current context is favourable to fuels that are more environmentally friendly. However, this environmental advantage cannot be translated into an economic advantage in the absence of a reasonable carbon price.

Environmental considerations

Environmental considerations and in particular climate change considerations are an important factor that can enhance the role of gas in European power generation. International Agreements such as the Paris Agreement as well as European legislation developed in the framework of the Energy Union can incentivise the transition. The EU and its Member States played an important role in the negotiation of the 2015 Paris Agreement aiming to maintain:

'the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change' (The Parties to the Agreement 2015, Article 2). 2015 also happen to be the warmest year since global temperatures started to be recorded in 1880 (The World Bank Group 2016) so the Agreement was very timely.

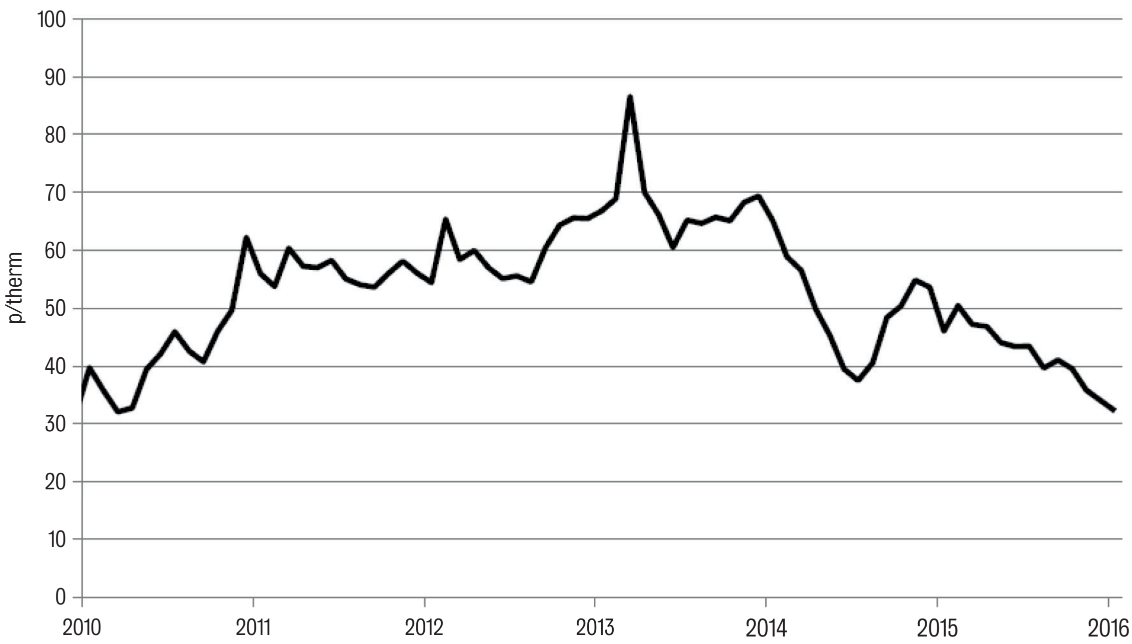
The Paris Agreement takes a bottom-up approach to tackling climate change as members submitted intended nationally determined contributions (INDCs) outlining the amount of GHG emissions reduction that states plan to embark on. The agreement entered into force in November 2016. Transformations in the energy sector and in particular

4 Solid fuels account for 43.7% (European Commission, DG Energy 2016, p.90).

5 Oil-indexed contracts for gas vs. spot prices.

6 The projections on the price of natural gas show that the prices will remain low for the foreseeable future, despite a predicted gradual increase (US Energy Information Administration 2016).

Figure 4: Monthly average day a head gas price 2010-2016, p/therm



Source: ICIS Energy 2016

in power generation are important for reaching the objective of the agreement as the energy sector accounts for two-thirds of GHG emissions (International Energy Agency 2016). According to the International Energy Agency, the growth of energy-related CO_2 emissions stopped in 2015 as a result of the lower energy intensity of the world economy triggered by increase in energy efficiency and the increased use of cleaner energy worldwide. The goals set by the EU to combat climate change have impacted EU environmental and energy policies and legislation in the past years. An important area of regulation is that of the carbon market.

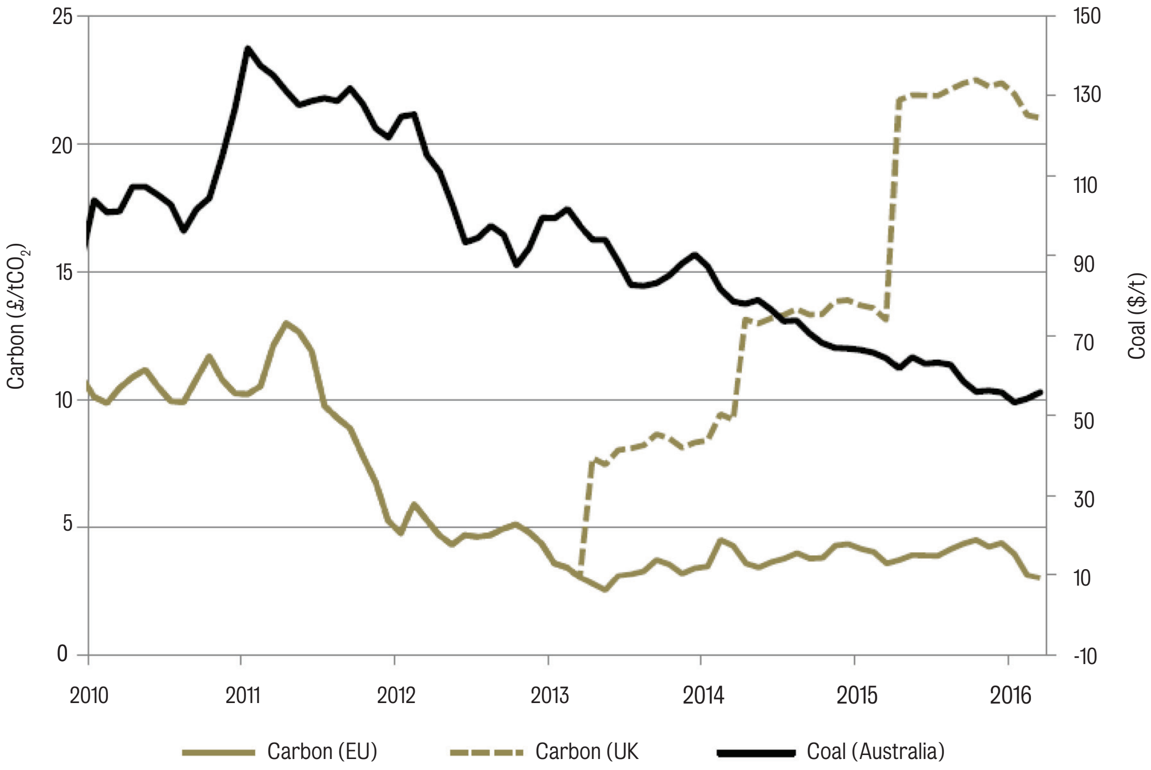
Regulation

Changes in regulation have the potential to support a greater role for gas at the EU and Member States levels. The EU does not practice a carbon tax, but the EU developed the EU Emissions Trading System (EU ETS). The development of EU ETS was a consequence of the EU signing and ratifying the 1997 Kyoto Protocol that set legally binding emission reduction targets (caps) for industrialized states. The EU ETS is supposed to help the EU 'reduce greenhouse gas emissions by at least 40% domestically by 2030 in line with the 2030 climate and energy policy framework and as part of its contribution to the Paris Agreement' (European Commission 2015). Developed as a regional policy instrument, there was great hope that the EU ETS could be developed into a global system.

The system provides for an overall cap on the European GHG emissions due to decrease annually until emissions are phased out. The rate of decrease of the EU-wide cap is currently 1.74% year for fixed installations. Within that cap power plants (and other fixed installations) receive an allowance that they can trade among each other. The mechanism was supposed to add to the cost of electricity the cost of carbon and incentivize operators to invest in power plants that generate less carbon. The system failed to properly deliver so far. The global economic crisis (reducing carbon emissions more than anticipated) and high imports of international credits generated a surplus of emission allowances on the EU market. In addition, certain sectors benefited from an excessive allocation of permits. Carbon prices have as a result fallen from €20/tCO_2e in 2011 (The Economist 2013) to €5/tCO_2e in 2013, and remain around this value currently.

In spring 2016, the United Nations Global Compact estimated that the minimum company internal price of carbon should be US$100/t$CO_2$e (by 2020) if the 1.5–2˚C Paris target is to be met (United Nations Global Compact 2016). Not surprisingly, in the last years, there was substantial debate in Brussels on how the EU ETS can be reformed in order to ensure a higher price of carbon. Through back-loading, the European Commission postponed auctioning 900 million emission allowances until 2019-2020. The impact assessment conducted by the European Commission showed that this mechanism can help accommodate the allowances to the unexpected supply and keep the price of carbon high with limited impact on the EU competitiveness (European Commission 2012). The allowances will be transferred to a market stability reserve rather than being auctioned off. The role of the reserve,

Figure 5: Monthly average carbon prices in Europe and the UK, 2008-2016



Source: Bloomberg 2016a

due to start operating in January 2019, is to address the surplus of allowances currently on the market and increase the resilience of the system by creating adjustments in the supply of allowances (European Commission 2016b). Another mechanism that was suggested by the European Commission to address the market imbalance is faster reducing the annual emissions cap at a rate of 2.2%/year rather than 1.74%/year starting in 2021 (European Commission 2015). In addition, there is a plan to set up a fund that would support modernizing the power sector in the less affluent 10 Member States (European Commission 2015). These two measures are due to be implemented for the ETS phase 4 (2021-2030). Meanwhile the carbon prices remain low at €5/tCO_2e, as it was the case on 1 April 2016.

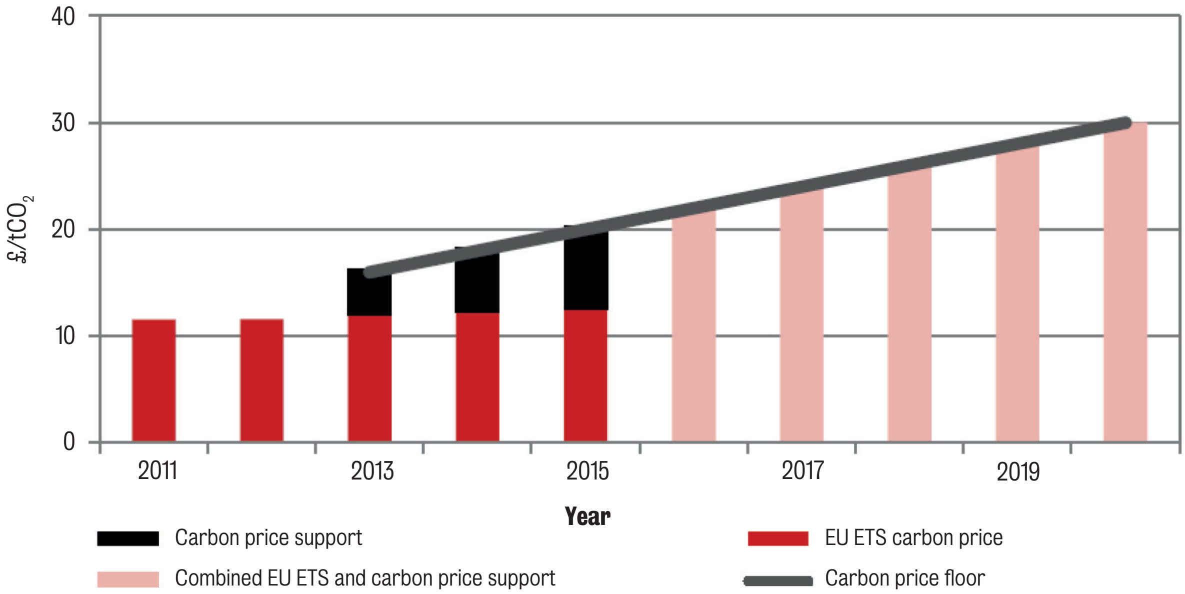
Measures to address the shortcomings of EU ETS were taken also at the national level. In the United Kingdom, greener power generation is supported through a carbon price floor (CPF). The CPF came into effect on 1 April 2013. The CPF is made up of the price of CO_2 from the EU Emissions Trading System (EU ETS) and the carbon price support rate per tCO_2. The carbon price floor requires industries to pay a top up if the market (EU ETS) price of carbon is lower than the CPF.

The floor aims to generate predictability when it comes to the carbon price and encourage investment in climate-friendlier power generation. The CPF did not fully insulate the UK carbon price from the low levels reached by carbon price in the EU ETS, but limited the impact of those price fluctuations in the UK. If the price of carbon paid by coal-fired plants in Germany was €5.89/tCO_2 on 9 May 2016, British plants paid €31.11/tCO_2 (Duhan 2016). Consequently, in the UK exists a stronger pressure to move away from coal in power generation. That being said, adjustments to carbon flooring needed to be made in 2014 in the UK (Her Majesty's Revenue and Customs, UK Government 2014) to mitigate the lower than anticipated price of carbon on the European market.

France also plans to introduce a carbon price floor of €30/tCO_2e applicable to the electricity sector starting in January 2017 (The Guardian 2016) and similar measures applicable to European carbon emissions are mentioned in the German energy and climate strategy through 2050 (Bloomberg 2016b). The floor is expected to especially favour nuclear power generation in France. However as it will be shown below nuclear energy is not a realistic alternative for countries such as Germany.

In addition to the Europe-wide EU ETS, carbon taxes have been recently embraced by several European states. A tax in France is applicable to the use of fossil fuels outside the EU ETS, for instance in the service, transport and residential sectors (The World Bank Group 2016). A carbon tax is practiced in Portugal starting in 1 January 2015 in relation to energy products outside the EU ETS (The World Bank Group 2016).

Figure 6: UK Carbon price floor illustration (in real 2009 prices and calendar years)[7]



Source: Her Majesty's Treasury 2011

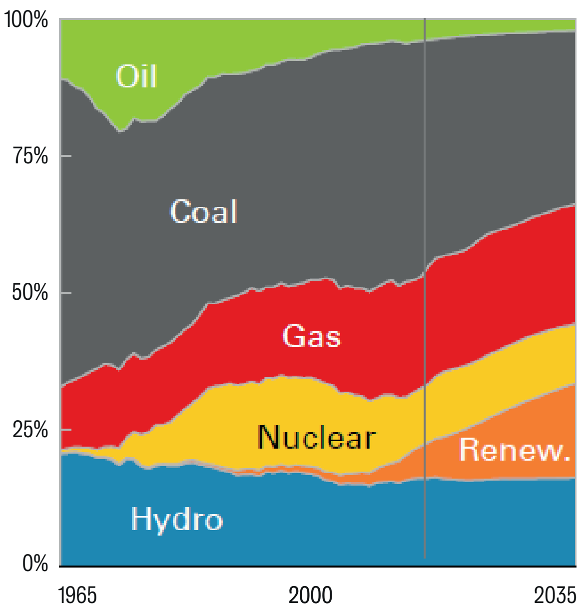
These shifts in Member States policy impact on the economical viability of fuels in the energy mix of European states. While member states of the EU have sovereignty over their individual energy mix under Art.194 in the Treaty on the Functioning of the European Union (European Union Member States 2009), carbon taxation mechanism triggered by EU-level climate commitments can assist in a switch from relatively cheaper and domestic available fuels that are CO_2 intensive, such as coal, to gas.

Technological changes

Power generation based on renewable energy comes with lower emissions than power generation from gas, but technological limitations (mainly related to consistent power generation and power storage) undermine a power generation system completely based on renewable energy. For the time being, gas can act as a valuable partner to renewable energy in a cleaner energy system.

The share of renewable sources in EU-28 electricity generation increased from 13.5% in 2004 to 24.9% in 2014 while generation from fossil and nuclear sources is on the decrease (Eurostat 2016).[8] The future seems to look bright for renewables at the global level: 'nearly 60% of all new power generation capacity to 2040 in our main scenario comes from renewables and, by 2040, the majority of renewables-based generation is competitive without any subsidies' (International Energy Agency 2016). Renewables are due to become the most important source of power generation around the year 2030 in Europe (International Energy Agency 2016). Forecasts developed by industry support the IEA assumptions regarding the increased role of renewables, although they are less optimistic:

Figure 7: Primary inputs to power generation



Source: British Petroleum, BP Energy Outlook, 2016 edition

7 The figure illustrates the carbon price floor launched in the UK as designed initially, in 2011. In this figure, the numbers for the EU ETS carbon price after 2011 are just illustrative (estimates that were eventually not met).

8 'there was a relatively large decrease in the importance of combustible fuels from 55.9 % to 47.6 % and also a reduction in the share of electricity generated from nuclear power plants from 30.6 % to 27.4 %' (Eurostat 2016).

However, renewables-based generation is prone to fluctuations dependent on weather conditions. According to the same International Energy Agency publication, more conventional plants that can dispatch at short notice will have to help tackle the variability of renewable (wind, solar) generation at least 'up until they reach a share of around one-quarter in the power mix' (International Energy Agency 2016, p.5).

Technological limitations associated with both coal and nuclear power place gas power plants in a good position. If sulphur emissions provided a strong argument for replacing coal with gas in power generation in the UK in the 1980s-1990s, CO_2 emissions pose a problem to coal in a political and economic environment increasingly concerned with climate change. The lack of substantial progress in the field of carbon capture and storage technologies places coal at a significant disadvantage in relation to gas when comparing the carbon footprint of the two.[9]

As it was the case twenty years ago, when the *dash for gas* took place, social acceptance of nuclear energy remains low. If the 1986 Chernobyl accident triggered important social opposition to nuclear power in Europe in the 1990s, the nuclear accident at the Fukushima nuclear power plant in March 2011 led to important policy changes. For instance, by 2022, Germany aims to phase out its nuclear plants that currently account for 15.47% of the national power generation (European Commission, DG Energy 2016, p.90). Security concerns regarding the use of this technology persist.

The revolution in the electric car can mean an increasingly feasible and cleaner alternative to the oil-propelled car. Estimates show that by 2040 there could be 715 million electric cars in use (International Energy Agency 2016, p.4). This might substantially increase the demand for electricity. The share of electricity in global energy consumption is due to increase: 'electricity accounts for almost 40% of additional consumption to 2040 in our main scenario and for two-thirds in the 450 Scenario' (International Energy Agency 2016, p.3). A higher demand for electricity might open avenues for a higher contribution of gas to power generation. Electricity and gas are already predicted to increase their share in the global energy mix of the future (International Energy Agency 2016).

As showed above, several factors (cheap gas, environmental commitments, regulatory changes and technological drives) seem to indicate that there is a chance that a switch to gas in power generation similar to that taking place in the UK in the 1990s can take place in Europe in the next years. The next section will address areas of policy uncertainty that might impact the prospects of gas before we explore the ways in which the likelihood of a switch to gas in power generation can be increased.

9 Advances in carbon capture and storage can also enhance the role of gas in power generation on the long term. In general, advances in CCS will benefit all the energy sectors that generate carbon and the energy-intensive economic sectors.

Areas of policy uncertainty

Given the Brexit vote, the EU is now faced with a strong partner in climate policy leaving the Union. Questions arise on how Britain leaving the EU will affect its membership to the Emission Trading System (ETS). Britain has the second largest carbon market in the EU, after Germany, therefore its withdrawal from the scheme will have an effect on the ETS in terms of demand and supply and the shape of the currently re-negotiated system. However, it is likely that the UK remains a partner to the scheme in the future. As discussed earlier, the UK has made efforts in reducing its own carbon market, alongside supporting the ETS, by introducing the Carbon Price Floor (CPF), in an effort to attract investment in low carbon power generation. The price for carbon is linked to the EU ETS price and it is likely that there will be a form of future cooperation. There are already models for membership to the EU ETS for non-EU countries and the UK could, for example, follow the Norwegian model and become part of the EU ETS through EEA membership. But even in the scenario in which the UK would negotiate an independent free trade agreement with the EU, it is likely that the EU ETS would form part of the agreement as the linkage already exists with the CPF.

Another question raised in the aftermath of the referendum was that of the UK's commitments under the Paris agreement and whether the UK would ratify the agreement pre- or post-Brexit. A post-Brexit ratification would have left space for re-negotiation of targets for Britain. On 17 November 2016, the UK ratified the agreement and therefore remains commitment to working with the EU and other countries on the environment and climate change (The Select Committee on the European Union, Energy and Environment Sub-Committee 2016).

The US elections taking place on the 8th of November led to Donald J Trump being elected the 45th President of the United States. At the same time, the Republican Party secured a majority in both the Senate and the House of Representatives that is likely to offer a strong back up to the policies advanced by the Trump administration. Donald Trump's position on renewable energy and climate change has been inconsistent over the last years, but he remains known for claiming in 2012 that: 'The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive' (Trump, quoted in Bump 2016). Trump also openly rejected the Paris Agreement in its current form. To a certain degree, the situation reiterates the events that surrounded the signing of the Kyoto Protocol (by the outgoing Clinton administration on 12 November 1998), just to face opposition from the Senate and be criticised by the Republican George W Bush administration.

The prospects that the Paris Agreement is facing are somehow different. The Agreement was signed by the US during the Obama administration and it did get ratified on 3 September 2016, on the same day as the Agreement was ratified by China. This makes the agreement legally binding for the United States for at least the next four years, during most of the mandate of President Trump. However, even if the US will remain party to the agreement, its incentives to meet its GHGs reduction targets (by 2025, 26% to 28% reduction by contrast to 2005 levels) will be low as there are no penalties for lack of compliance (Dingwerth 2016). The US lack of compliance might trigger a chain effect around the world and jeopardize the Agreement (Dingwerth 2016). Governments will be under the pressure of national industries arguing that national climate commitments determine them to lose competitiveness to American firms. Immediately after the results of the elections were announced, the climate policy-making community in Europe expressed its concern regarding the prospects faced by the Paris Agreement and the hope that US will remain committed to it and EU-US cooperation on climate (Crisp 2016).

Initial steps taken by Donald Trump confirm his climate scepticism. Trump's Environmental Protection Agency (EPA) transition team is led by a climate sceptic, Myron Ebell, who has argued in the last years that climate change concerns are exaggerated (Boccagno 2016). Recently, it was announced that EPA will be led under the Trump administration by Scott Pruitt, Oklahoma's Attorney General, who in recent years legally fought new regulation on air and water pollution, including the Clean Power Plan, an Obama policy aiming to reduce carbon dioxide emissions generated by power plants (US Environmental Protection Agency 2016b). Budget for climate research might also be substantially cut. There are plans to scrap climate change from NASA's research agenda as senior Trump adviser claims that it contributes to the politicisation of research and affects its quality (Bulman 2016).

Of course, we are going to have a better idea of the developments in the United States in a few weeks when it becomes clearer what the Trump administration brings in the field of climate and energy policy, especially as Donald Trump did not base his campaign on detailed policy recommendations. To a certain degree the anti-climate position served Trump very well in attracting voters in the Rust belt. It remains to be seen the degree to which electoral promises will be converted to political reality especially as there is already a lot of international pressure on Trump to keep the United States internationally engaged on climate change (Barbière 2016). The general expectation is that the strong anti-climate position of Donald Trump will be watered down. Some signs of a milder approach are already visible. Although Trump was always reluctant to admit that there is a connection between human action and climate change (meaning that climate change is not a natural phenomenon and that change in human action can prevent it), a very recent interview in New York Times points to a possible change in his position, with Trump admitting that there is some connectivity between human activity and climate change: 'I think there is some connectivity. There is some, something. It depends on how much. It also depends on how much it's going to cost our companies' (Trump, interview in The New York Times 2016).

A proper implementation of the Paris Agreement by the US that would lead to the global taxation of carbon will make the gas industry in Europe more competitive by comparison with the coal industry, but on the very long term it might reduce its prospects. A gas and fossil fuels friendly President Trump might encourage similar positions around the world. What implications such a move will have on the climate and energy systems on the mid and long term remains to be seen.

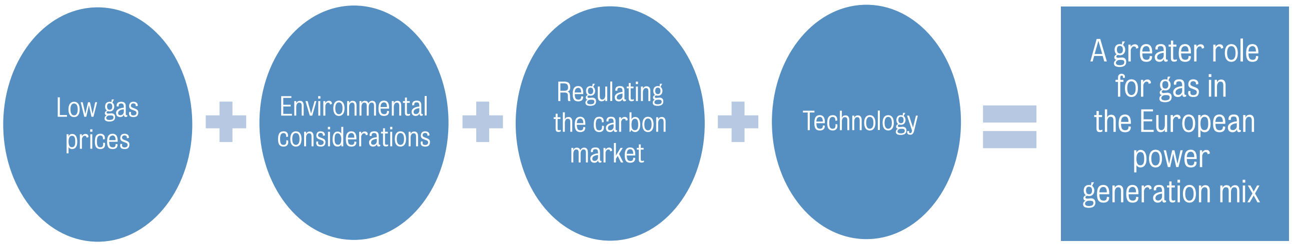
In addition to potential changes brought by Brexit and the Trump administration, changes in EU regulation currently under debate are likely to impact the prospects of gas in power generation in the EU. For instance, tougher methane emissions regulations might attach additional costs to gas production in Europe. The request of the European Commission to Member States to allow it to vet oil and gas contracts with suppliers in third countries in order to ensure better compliance with the EU law was approved on 7 December 2016. This new development might delay or block the closing of certain gas contracts and impact the amount of gas available on the EU market. The development of Nord Stream 2 (an extension of Nord Stream 1, a pipeline bringing natural gas from Russia to Germany, and implicitly to the Western European market, under the Baltic Sea) is surrounded by substantial controversy. The pipeline has triggered opposition from many Central and European countries, as well as from the United States, on the grounds that it will increase the EU dependence on Russian gas. The realisation of the pipeline will impact the availability of Russian gas on the European market and most likely the price of natural gas available to Europeans.

Conclusion

The previous section of the paper has investigated the degree to which drivers that contributed to the UK's *dash for gas* are present today in Europe and could point towards a future in which gas plays a more important role in power generation. The paper showed that we seem to have the same combination of low gas prices, environmental considerations (in particular climate considerations) that might favour gas over coal and create financial incentives for the use of gas in power generation by pricing carbon. This section also showed that technological limitations associated to alternative power sources (renewable, coal, nuclear) place gas in a good position to remain an important component of the European power generation mix in the future.

In addition to these factors, a free, liberalised energy market backed up by strong EU legislation that encourages competition and discourages monopolies in energy generation and transmission renders the overall current European political and economic climate very similar to the climate in which the *dash for gas* took place in the UK in the 1990s. That being said, there are several challenges gas is facing at the EU and Member States levels. There is a climate of political and legal uncertainty generated by des-integrationist tendencies, such as Brexit, or by powerful contestation of energy and environmental norms, such as the election of Donald Trump in the United States. In addition, as showed above, the outcomes of several regulatory initiatives of the European Commission might impact the legal and policy landscape in which the gas industry and gas industrial consumers operate in Europe. This is not to say that these challenges cannot be overcome as long as there is political will on behalf of governments and desire to engage in carving a better future for gas in Europe in the industry.

Figure 8: Factors that can lead to a greater role for gas in the European energy mix



Source: Figure developed by the authors of the study

Policy recommendations

What measures can the European policy-makers and stakeholders take to enhance the role of gas in power generation in Europe? Before embarking on making policy recommendations, this study acknowledges that developments in the field of energy markets can be unpredictable and any speculation on their future needs to be advanced with caution. That being said, the paper will put forward several policy recommendations that should open a path for natural gas as a partner to renewable energy in the future EU energy mix on the assumption that major political transformations do not take place in the near future (this paper took into account political transformations such as Brexit and the implications of a Trump administration on global energy and climate policy).

Providing financial incentives for the use of gas in power generation

Despite the decline in the price of gas and the potential that it presents in power generation by complementing renewables, the financial incentives for natural gas are not strong enough. The right economic incentives need to be provided for power generation to rely more on gas in Europe in general and particularly in Germany, which is still relying substantially on coal in power generation. In great part the UK's *dash for gas* of the 1990s was determined by the abundance of cheap gas on the UK market (Spooner 1995, Winskel 2002). The drop in the price of gas imports to Europe in the last years (4.51 USD/MMBtu for Jul 2016) should provide a financial incentive for a shift to gas in power generation in Europe. However, with cheap coal available on the European market and heavily subsidized renewable energy that is given priority on the power exchange markets, there is not enough financial incentive for a shift to gas. The higher carbon footprint of coal is not currently reflected in the price of power generated by coal-fired stations and incentivizes the investment in coal power plants (The Economist 2013). Fixing the faulty European carbon market is a priority.

As partners to renewable energy facilities in future power generation, gas power plants can play an important role in reducing the generation fluctuations inherent to renewable sources (triggered by weather conditions, day/night variations, etc.). In a system in which renewable energy is prioritised, gas power plants might run only a few hours a day. However, the generation stability that they bring to the system is essential for its proper functioning. This stability is a type of public good that should be supported through financial and regulatory measures.

Effectively taxing carbon

At the European level, since 2005 the EU Emissions Trading System aims to create financial incentives that would encourage a move away from carbon intensive industrial activity and power generation. The EU ETS has proven to be an imperfect instrument in supporting the EU Member States in reaching their climate commitments. There is a strong consent at the international level that Paris Agreement objectives can only be met by pricing carbon through a carbon tax or an emissions trading system. Over 90 INDCs mention the use of carbon pricing initiatives and Parties covering 60% of the global GHG emissions mentioned in their INDCs contemplating using market mechanisms to reach their emissions reduction target (The World Bank Group 2016). The failure of the EU ETS can be limited by resorting to alternative mechanisms such as carbon flooring (adopted by the UK) or a carbon tax (adopted by France). A system of flooring and ceiling prices was adopted also outside Europe, for example by California (The Economist 2013).

Upholding environmental commitments

According to the latest assessment made by the International Energy Agency the EU, US and Japan seem to be more or less on track in meeting their climate objectives (International Energy Agency 2016), but doubts remain if the pledges taken at Paris are enough to limit the temperature increase to 2°C. Even in the context of Brexit, Member States, including the UK, remain committed to the pledges to stop climate change they took in Paris in 2015. From the data that we have so far Brexit should have a limited impact on the European climate effort, although debates on this topic are ongoing in the British Parliament (The Select Committee on the European Union, Energy and Environment Sub-Committee 2016).

At the same time, the result of the US elections indicates that the new American administration will be less committed to fighting climate change than the Obama administration. Although it is unlikely that the US will effectively withdraw from the Paris Agreement in the next years[10], the degree to which the US will deliver on its nationally determined contributions is a matter of debate. It is important for European and EU leaders to engage the Trump administration on issues related to climate and even resort to issues linkage (for instance, conditioning cooperation in the field of trade by US remaining engaged in the climate regime) in order to project the European climate policy preferences. The European Union played an instrumental role in the negotiation and signing of the Paris Agreement and now it will have to rise to the challenge of protecting its achievements. The summit that led to the negotiation of the agreement was hosted by France. France

10 A country can withdraw from the Agreement only in three years and it would take another year for that withdrawal to become effective. Even if the US was to abandon the Paris agreement it could still produce considerable positive impact as long as the other Parties and in particular the main polluters remain committed.

has been a strong political supporter of the agreement ever since, including through the voice of its President that recently urged Donald Trump to keep the commitments that US took under the Paris Agreement (Barbière 2016). Other European leaders should follow, politically and diplomatically engaging Donald Trump on climate matters.

Supporting research that would foster technological progress

Technological progress can greatly enhance the prospects of low-carbon technologies in power generation. Over the last years, advances in fracking technology led to increased hopes regarding the future availability of cheap gas on global and regional markets. Advances in technology that would allow us to better keep track of various GHGs can help us further expand the scope of the EU ETS (for instance, to other economic sectors) and develop other mechanism that allow for accurately taxing pollution. Technology enabling smarter grids can help better integrate renewable energy and gas in the power generation sector. The European Union and the EU Member States can foster technological progress by financially contributing to research and development in these particular fields.

Rethinking European energy security in an era of interdependence

Unlike in the case of the UK in the late 1980s and early 1990s, the decrease in the price of gas is not coupled with the availability of abundant domestic and 'secure' gas. Concerns remain regarding the implications that an increased dependence on natural gas in power generation has for EU energy security. Predictions are showing that the amount of gas that the EU imports will increase in the future given that domestic production is declining, while consumption is due to increase. Russia remains an important European source of natural gas: 'in 2015 as a whole, Russian supplies represented 40% of total extra-EU imports, followed by Norway (37%), Algeria (7%) and Libya (2%); LNG imports covered the remaining 13%.' (European Commission 2016a, p.2)[11]. Policy-makers in Brussels and in several European capitals regard an increasing dependence on Russian gas with wariness. However, these fears are not shared by German officials who regard the relation with Russia as one of mutually beneficial interdependence rather than dependence and there are plans to increase the degree of this interdependence through Nord Stream 2. This is due to the experience of reliable gas relations with Russia even through the heights of the Cold War and the relationship of interdependence established between Germany and Russia in the gas field. Demand security is viewed as important for Russia as supply security is for Germany.

Several steps were taken in recent years towards developing a single European market (reverse flow mechanism were set, interconnectors developed, LNG terminals were built, etc.), which question European supply security concerns. But EU member states will remain dependent on Russian gas for the foreseeable future and Russia also remains dependent on supplying gas to Europe. The physical proximity to Europe places Russia at a competitive advantage as a pipeline gas supplier to Europe. Therefore the EU's efforts should not be directed only to diversifying away from Russian gas, but be also to ensuring a political and commercial stable relationship with Russia. A switch in the understanding developed in Brussels of energy security as independence from Russia to energy security as interdependence with various gas suppliers could lead to a higher acceptance of gas as a secure source of power generation.

There are good prospects for an enhanced role of gas in power generation (most likely in partnership with renewable energy) in the European Union in the next years. The contribution that gas will make to the power mix is dependent on several factors (evolution of the fuel prices, changes in technology, etc.), but also on public policy. Market forces, the gas industry and governments can jointly contribute to enhancing the role of gas in European power generation on the mid- and long-term.

11 In both the last quarter of 2015 and the first quarter of 2016, import volumes were significantly higher than in the previous year, with the biggest increases coming from Russian and Algerian supplies. LNG imports increased in the last quarter of 2015 but decreased in the first quarter of 2016 on a year-on-year basis.' (European Commission 2016a, p.2).

References

A

Andrews, David (1988) 'Joining forces', *International Power Generation*, pp.19-22.

B

Barbière, Cécile (2016) *Hollande to Trump: Paris Agreement is 'irreversible'*, EurActiv, 16 November 2016, available at: http://www.euractiv.com/section/climateenvironment/news/hollande-to-trump-the-paris-agreement-is-irreversible/, accessed 20 November 2016.

Bloomberg (2016a) in Ofgem report *Wholesale energy markets in 2016*, available at: https://www.ofgem.gov.uk/system/files/docs/2016/08/wholesale_energy_markets_in_2016.pdf, accessed 14 December 2016.

Bloomberg (2016b) *Germany considers minimum EU carbon price in energy policy draft*, 14 May 2016, available at: http://www.bloomberg.com/news/articles/2016-05-04/germany-considers-minimum-eu-carbon-price-in-energy-policy-draft, accessed 5 November 2016.

Boccagno, Julia (2016) *Climate change denier is leading Trump's EPA transition team*, CBS News, 11 November 2016, available at: http://www.cbsnews.com/news/leading-climate-change-denier-among-those-on-trumps-environmental-team/, accessed 15 November 2016.

Bulman, May (2016) *Donald Trump to scrap Nasa's climate change research because it is 'too politicised'*, The Independent, 23 November 2016, available at: http://www.independent.co.uk/news/world/americas/donald-trump-climate-change-nasa-global-warming-bob-walker-a7433146.html, accessed 25 November 2016.

British Petroluem, BP (2014) *BP marks five decades in the North Sea*, available at: http://www.bp.com/en/global/corporate/bp-magazine/locations/north-sea-at-50.html, accessed 22 November 2016.

British Petroleum, *BP (2016) BP Energy Outlook, 2016 edition, Outlook to 2035*, available at: http://www.bp.com/en/global/corporate/energy-economics/energy-outlook-2035.html, accessed 12 December 2016.

C

Crisp, James (2016) *Trump can kill UN climate deal, warns EU carbon market chief*, EurActiv, 9 November 2016, available at: http://www.euractiv.com/section/climate-environment/news/trump-can-kill-un-climate-deal-warns-eu-carbon-market-chief/, accessed 11 November 2016.

D

Department for Business, Energy and Industrial Strategy, UK Government (2016) *Energy Trends: September 2016,* available at: https://www.gov.uk/government/statistics/energy-trends-september-2016, accessed 12 November 2016.

Department of Energy and Climate Change (2016) *2014 UK greenhouse gas emissions: final figures – statistical release*, 2 February 2016, available at: https://www.gov.uk/government/statistics accessed 10 December 2016.

Department of Trade and Industry (1997) *Digest of United Kingdom Energy Statistics 1997*, London: Her Majesty's Stationery Office

Department of Trade and Industry and the Scottish Office (1995) *The prospects for nuclear power in the UK*, London: Her Majesty's Stationery Office.

Dingwerth, Klaus (2016) *How Trump can quit the Paris Agreement*, EurActiv, 15 November 2016, available at: http://www.euractiv.com/section/climate-environment/opinion/how-trump-can-quit-the-paris-agreement/, accessed 25 November 2016.

Duhan, Matthew (2016) *Carbon pricing in Europe: where the UK and France leads, will Germany follow?*, Insidetrack, 20 May 2016, available at: https://greenallianceblog.org.uk/2016/05/20/carbon-pricing-in-europe-where-the-uk-and-france-leads-will-germany-follow/, accessed 25 October 2016.

E

European Commission (2012) *Proportionate impact assessment accompanying the document Commission Regulation (EU) amending Regulation (EU) No 1031/2010 in particular to determine the volumes of greenhouse gas emission allowances to be auctioned in 2013-2020*, available at: http://ec.europa.eu/clima/policies/ets/reform/index_en.htm, accessed 22 November 2016.

European Commission (2015) *Proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments*, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015PC0337, accessed 23 November 2016.

European Commission (2016a) *Quarterly report on European gas markets: 2015 Q4 & 2016 Q1*, available at: https://ec.europa.eu/energy/en/data-analysis/market-analysis, accessed 15 November 2016.

European Commission (2016b) *Structural reform of the EU ETS*, available at: http://ec.europa.eu/clima/policies/ets/reform/index_en.htm, accessed 22 November 2016.

European Commission, *DG Energy (2016) Energy Statistical Pocketbook*, available at: https://ec.europa.eu/energy/en/data-analysis/energy-statistical-pocketbook, accessed 22 November 2016.

European Union Member States (2009) *The Treaty on the Functioning of the European Union*, available at: http://www.lisbon-treaty.org/wcm/the-lisbon-treaty/treaty-on-the-functioning-of-the-european-union-and-comments.html, accessed 12 October 2012.

Eurostat (2016) *Electricity production, consumption and market overview*, available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview#Electricity_generation, accessed 20 November 2016.

H

Her Majesty's Revenue and Customs, UK Government (2014) *Carbon price floor: reform and other technical amendments*, available at: https://www.gov.uk/government/publications/carbon-price-floor-reform, accessed 1 September 2016.

Her Majesty's Treasury (2011) *Carbon price floor consultation: the Government response*, available at: https://www.gov.uk/government/consultations/carbon-price-floor-support-and-certainty-for-low-carbon-investment, accessed 30 October 2016.

House of Commons Energy Committee (1990) *The flue gas desulphurisation programme* in Winskel, Mark (2002) 'When systems are overthrown: the "dash for gas" in the British electricity supply industry', *Social Studies of Science*, 32:4, pp.563-598.

I

ICIS Energy (2016) in Ofgem report *Wholesale energy markets in 2016*, available at: https://www.ofgem.gov.uk/system/files/docs/2016/08/wholesale_energy_markets_in_2016.pdf, accessed 14 December 2016.

International Energy Agency (2016) *World Energy Outlook 2016*, available at: https://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html, accessed 28 November 2016.

S

Schaefer, Keith (2009) *Natural gas price chart 1980-2007*, based on US Energy Information Administration and US Department of Commerce data, available at: https://oilandgas-investments.com/2009/investing/natural-gas-price-chart-1980-2007-some-bullish-signs/, accessed 25 November 2016.

Seymour, Richard (2012) *A short history of privatisation in the UK: 1979-2012*, The Guardian, 29 March 2012, available at: https://www.theguardian.com/commentisfree/2012/mar/29/short-history-of-privatisation, accessed 16 November 2016.

Smith, Roger and Michael Sharpe (1995) 'Rye House – a further step in the use of gas for power generation', *Power Engineering Journal*, 9:1, pp.33-40.

Spooner, Derek (1995) 'The "dash for gas" in electricity generation in the UK', *Geography*, 80:4, pp.393-406.

T

The Director of Engineering at Rolls-Royce Industrial Power Group (1994) in Winskel, Mark (2002) 'When systems are overthrown: the "dash for gas" in the British electricity supply industry', *Social Studies of Science*, 32:4, pp.563-598.

The Economist (2013) *ETS, RIP?*, 18 April 2013, available at: http://www.economist.com/news/finance-and-economics/21576388-failure-reform-europes-carbon-market-will-reverberate-round-world-ets, accessed 5 November 2016.

The Guardian (2016) *France sets carbon price floor*, 17 May 2016, available at: https://www.theguardian.com/environment/2016/may/17/france-sets-carbon-price-floor, accessed 30 October 2016.

The Managing Director of National Power (1993) in Spooner, Derek (1995) 'The "dash for gas" in electricity generation in the UK', *Geography*, 80:4, pp.393-406.

The Parties to the Agreement (2015) *Paris Agreement,* available at: http://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf, accessed 20 May 2016.

The Select Committee on the European Union, Energy and Environment Sub-Committee (2016) *Corrected oral evidence: Brexit: Environment and climate change*, latest evidence, 16 November 2016, available at: http://www.parliament.uk/business/committees/committees-a-z/lords-select/eu-energy-environment-subcommittee/inquiries/parliament-2015/brexit-environment-and-climate-change/, accessed 20 November 2016.

The World Bank Group (2016) *Carbon Pricing Watch 2016*, available at: https://openknowledge.worldbank.org/handle/10986/24288, accessed 20 November 2016.

Trump, Donald, interview in The New York Times (2016) *Donald Trump's New York Times interview: Full Transcript*, The New York Times, 23 November 2016, available at: http://www.nytimes.com/2016/11/23/us/politics/trump-new-york-times-interview-transcript.html?_r=0, accessed 24 November 2016.

Trump, Donald, quoted in Bump, Philip (2016) *What's Donald Trump's position on climate change? All of them.*, The Washington Post, 22 November 2016, available at: https://www.washingtonpost.com/news/the-fix/wp/2016/11/22/whats-donald-trumps-position-on-climate-change-all-of-them/, accessed 24 November 2016.

U

United Nations Global Compact (2016) *UN Global Compact calls on companies to set $100 minimum internal price on carbon*, 22 April 2016, available at: https://www.unglobalcompact.org/news/3381-04-22-2016, accessed 30 October 2016.

US Energy Information Administration (2016) *Short-term energy outlook*, available at: https://www.eia.gov/forecasts/steo/report/natgas.cfm, accessed 22 November 2016.

US Environmental Protection Agency, EPA (2016a) *Understanding global warming potentials*, available at: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials, accessed 23 November 2016.

US Environmental Protection Agency, EPA (2016b) *Clean Power Plan for existing power plants*, available at: https://www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants, accessed 14 December 2016.

Winskel, Mark (2002) 'When systems are overthrown: the "dash for gas" in the British electricity supply industry', *Social Studies of Science*, 32:4, pp.563-598.

Yorkshire Electricity (1995) 'Gas supply and Yorkshire electricity', *UK Centre for Economic and Environmental Development Bulletin*, 47, pp.11-12.

EUCERS

European Centre for Energy and Resource Security

The European Centre for Energy and Resource Security (EUCERS)

Department of War Studies
King's College London
Strand
London WC2R 2LS
Email info@eucers.eu
Telephone 020 7848 1912
www.eucers.eu